SIMULATIONS OF PUU OO LAVA FLOWS ON MARS. LS Glaze[1], SM Baloga[1], SA Stockman[1], JA Crisp[2], [1]Proxemy Research, Laytonsville, MD, 20882. [2]California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA, 91109.

Longitudinal thickness profiles are simulated for lava flows on Mars, erupted under identical conditions to Phase 2 of the Puu Oo eruption. Data on the thickness, width, slope, and advance rates [1] are used in two emplacement models to infer the systematic rheologic change along the flow path. The models subsequently provide a basis for scaling the thickness and advance rates to account for the difference in Mars gravity.

An elementary laminar Newtonian flowrate is used in the first emplacement model where the volumetric flowrate depends on the thickness cubed. The steady state solution for the relative viscosity is

$$\frac{\nu(x)}{\nu_o} = \frac{h(x)^3}{h_o^{\,3}} \frac{w(x)}{w_o} \frac{\sin\theta(x)}{\sin\theta_o} \qquad \textbf{(1)}$$

The second emplacement model is more characteristic of complex geologic materials such as lava floods, lahars, debris flows, and mud flows. In contrast to the Newtonian model, such natural flows often feature highly disrupted stream lines and produce volumetric flow rates that typically depend on the thickness to approximately the 3/2 power (see [2-5] and refs cited therein). In this case the steady state solution for the coefficient of friction is

$$\frac{C(x)}{C_o} = \frac{h(x)^3}{h_o^{\,3}} \frac{w(x)^2}{w_o^{\,2}} \frac{\sin\theta(x)}{\sin\theta_o} \qquad \textbf{(2)}$$

Figure 1 shows the relative viscosity increase with distance from the vent for Phase 2 of the Puu Oo eruption. Also shown is the increase in the coefficient of friction for the empirical model. Both of these curves highlight the sensitivity of the derived rheological properties to the measurements of thickness, width, and slope. Part of this difficulty can be mitigated by using the advance rate as a surrogate for the flow depth. In Figure 2, the relative viscosity and coefficient of friction have been determined by replacing $h(x)/h_o$ in Equations (1) and (2) with

$$\frac{h(x)}{h_o} = \frac{u_o w_o}{u(x)w(x)} \qquad \textbf{(3)}$$

The relationship in Equation (3) holds when volume is conserved, and u(x) can be determined from the rate of flow advancement. From a measurement perspective, there is less uncertainty in the location of the flow front than the thickness measurements at the margin. It is our belief, therefore, that the resulting rheologic estimates using flow velocity are more reflective of the bulk properties of the flow than those made using flow depth measurements. Note that there is a significant difference in the absolute magnitude of the computed changes between Figures 1 and 2.

For comparable eruption conditions, flow advance rates are slower on Mars due to the lower gravity. One consequence is that flows are systematically thicker than their terrestrial analogs. A more subtle consequence is that longitudinal thickness profiles increase more steeply in response to incipient increases in rheologic changes. These conclusions hold for the elementary laminar Newtonian flow rate or the 3/2 power-law dependence characteristic of more complicated natural mass movements. Figure 3 depicts the depth of a simulated flow erupted on Mars using the width and underlying slope from Puu Oo Phase 2, and viscosity as determined by fitting a line through the data in Figure 2.

For terrestrial flows, dimensional data on the local thickness, width, and topography provide a crude estimate of the systematic behavior of rheologic changes along the flow path. However, this approach is extremely sensitive to variations in the width of the flow and how well measured thicknesses at the

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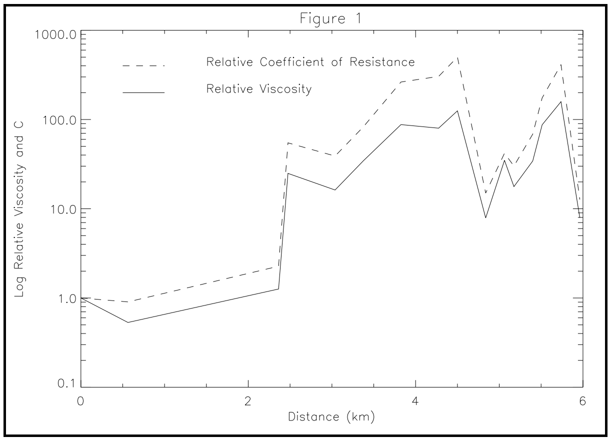
margins represent actual medial flow depths. Using the observed advance rate instead of thickness data provides a more reliable, continuous estimate of rheologic changes. This method also produces rheologic estimates that are systematically lower by a factor of 5 to 10. This approach is based on the assumptions of steady state conditions during emplacement and volume conservation along the path of a flow. Residuals between observed values and predictions exist for the flow depth or advance rate for either model. Whether these can be reduced by the relaxation of these assumptions remains to be determined.

References: [1] Wolfe, EW et al. (1988) USGS Prof Pap **1463**:1-99 [2] Crisp, JA and SM Baloga (1994) JGR **99**:11,819-11,831 [3] Canon-Tapia, E et al. (1996) JVGR **70**:21-36 [4] Baloga, S et al. (1995) JGR **100**:24,509-24,519 [5] Bruno, BC et al. (1996) JGR **10**: 11,565-11577



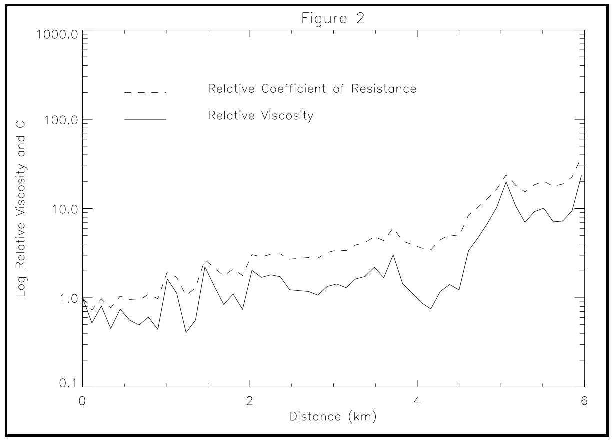


Table I. Variable definitions

Variable	Definition
x	distance
h	flow depth
w	flow width
θ	slope
ν	viscosity
C	coefficient of friction